Hydraulic Design
Custom Spa Systems

Spa Jet System Hydraulic Design

This section of the workbook is to help you calculate a balanced spa jet plumbing and pump system.

Calculating Pipe Size

1. Determine Total GPMs of Jet System. Calculate the size of the jets & quantity (use Jet Performance Flow Chart).

JET FLOW CHART

JETS				
NOZZLE ORIFICE SIZE	10 PSI	15 PSI	20 PSI	
3/16"	3	4	5	GPM
1/4"	6	7	8	GPM
5/16"	9	10	12	GPM
3/8"	13	16	18	GPM
7/16"	17	19	22	GPM
1/2"	24	29	33	GPM
3/4"	63	65	75	GPM
1"	95	116	134	GPM
1 1/8"	120	147	170	GPM
1 1/2"	213	260	301	GPM

EXAMPLE: **4 - Jets @ 15 GPM is 60 GPM @ 15 PSI (ie. Power Storm Gunite)**
8 - Jets @ 10 GPM is 80 GPM @15 PSI (ie. Poly Storm Gunite)
Totalling 140 GPM @ 15 PSI

Jet Type	*GPM*		*Quantity*		*Total GPM*		*PSI*
_____	_____	x	_____	=	_____	@	_____
_____	_____	x	_____	=	_____	@	_____
_____	_____	x	_____	=	_____	@	_____
_____	_____	x	_____	=	_____	@	_____
_____	_____	x	_____	=	_____	@	_____
_____	_____	x	_____	=	_____	@	_____
			TOTAL		_____		

2. Determine Jet Return Plumbing. Once the Total GPM is known you use the water velocity to calculate the pipe size for the trunk feed line. A suggested velocity of 7 fps* is reasonable for the discharge lines. From the Friction Flow Chart you can determine the size of pipe by comparing the GPM to the velocity.

FRICTION FLOW CHART

Friction loss of water in feet of head per 100 foot length of pipe.

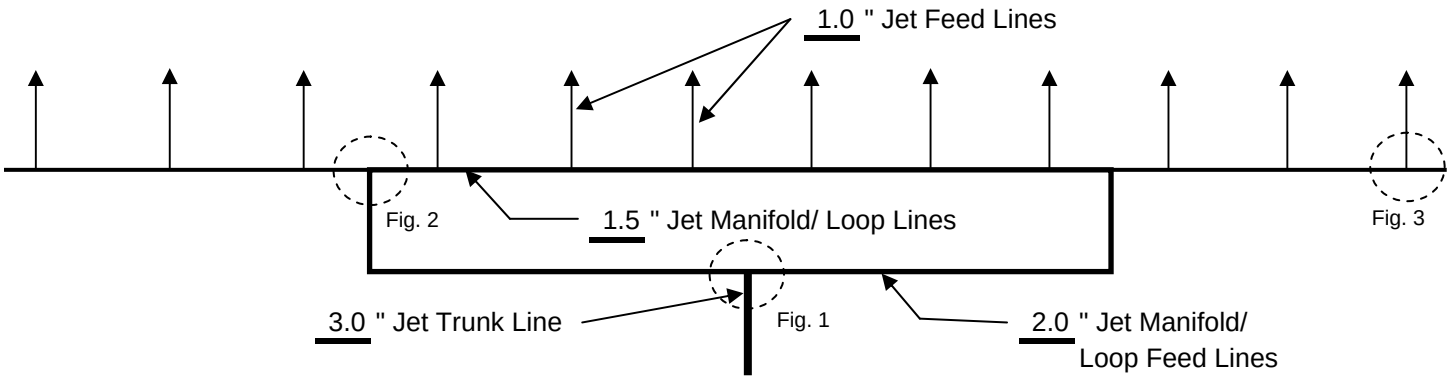
U.S.	3/4" PIPE			1" PIPE			1¼" PIPE			1½" PIPE			2" PIPE			2½" PIPE			3" PIPE		
Gal. per Min.	Vel. Ft. per Sec.	Loss in Feet	Loss in PSI	Vel. Ft. per Sec.	Loss in Feet	Loss in PSI	Vel. Ft. per Sec.	Loss in Feet	Loss in PSI	Vel. Ft. per Sec.	Loss in Feet	Loss in PSI	Vel. Ft. per Sec.	Loss in Feet	Loss in PSI	Vel. Ft. per Sec.	Loss in Feet	Loss in PSI	Vel. Ft. per Sec.	Loss in Feet	Loss in PSI
1	.60	.25	.11	.37	.07	.03	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2	1.20	.90	.39	.74	.28	.12	.43	.07	.03	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	1.80	1.92	.83	1.11	.60	.26	.64	.16	.07	.47	.07	.03	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	2.41	3.28	1.42	1.48	1.02	.44	.86	.25	.11	.63	.12	.05	.....	.....	.....	.....	.....	.....	.....	.....	.....
5	3.01	5.8	2.51	1.86	1.52	.65	1.07	.39	.17	.79	.18	.08	.....	.....	.....	.....	.....	.....	.....	.....	.....
6	3.61	7.0	3.0	2.33	2.15	.93	1.29	.55	.24	.95	.25	.11	.57	.07	.03	.....	.....	.....	.....	.....	.....
8	4.81	11.8	5.1	2.97	3.6	1.56	1.72	.97	.42	1.25	.46	.2	.76	.14	.06	.54	.05	.02	.....	.....	.....
10	6.02	17.9	7.75	3.71	5.5	2.4	2.15	1.46	.63	1.58	.69	.3	.96	.21	.09	.67	.09	.04	.....	.....	.....
15	9.02	37.8	16.37	5.57	11.7	5.07	3.22	3.07	1.33	2.36	1.45	.63	1.43	.44	.19	1.01	.18	.08	.65	.07	.03
20	.....	.....	.....	7.42	19.9	8.62	4.29	4.2	1.82	3.15	2.47	1.07	1.91	.74	.32	1.34	.30	.13	.87	.12	.05
25	.....	.....	.....	9.28	30.0	13.0	5.36	7.9	3.42	3.94	3.8	1.6	2.39	1.11	.05	1.67	.46	.2	1.08	.16	.07
30	.....	.....	.....	11.14	42.0	18.19	6.43	11.1	4.8	4.73	5.2	2.3	2.87	1.55	.67	2.01	.65	.28	1.30	.23	.1
35	.....	.....	.....	.....	.....	.....	7.51	14.7	6.37	5.52	7.0	3.03	3.35	2.06	.89	2.35	.88	.38	1.52	.30	.13
40	.....	.....	.....	.....	.....	.....	8.58	18.9	8.2	6.30	8.9	3.9	3.82	2.63	1.14	2.64	1.11	.48	1.73	.39	.17
45	.....	.....	.....	.....	.....	.....	9.65	23.5	10.18	7.09	11.1	4.8	4.30	3.28	1.4	3.01	1.39	.6	1.95	.48	.21
50	.....	.....	.....	.....	.....	.....	10.72	28.5	12.3	7.88	13.5	5.8	4.78	4.0	1.7	3.35	1.69	.73	2.17	.58	.25
60	.....	.....	.....	.....	.....	.....	.....	.....	.....	9.46	18.9	8.18	5.74	5.6	2.4	4.02	2.36	1.02	2.60	.81	.35
70	.....	.....	.....	.....	.....	.....	.....	.....	.....	11.03	25.1	10.9	6.69	7.4	3.2	4.69	3.14	1.36	3.04	1.09	.47
80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7.65	9.5	4.1	5.35	4.0	1.73	3.47	1.39	.6
90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.60	11.8	5.1	6.03	5.0	2.2	3.91	1.73	.75
100	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9.56	14.4	6.3	6.70	6.1	2.64	4.34	2.10	1.9
120	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11.95	21.8	9.4	8.38	9.2	4.0	5.42	3.19	1.38
150	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10.05	12.8	5.5	6.51	4.5	1.95
175	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7.59	5.9	2.55
200	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.68	7.9	3.4
225	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9.76	9.4	4.07
250	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	10.85	11.5	4.99
275	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
300	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
325	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

* National Spa & Pool Institute's and the Hydraulic Institute's standards maximum velocity for discharge plumbing is 10 fps & for the suction side 8 fps in Sch 40 PVC.

Calculating Pipe Size- Jet Discharge

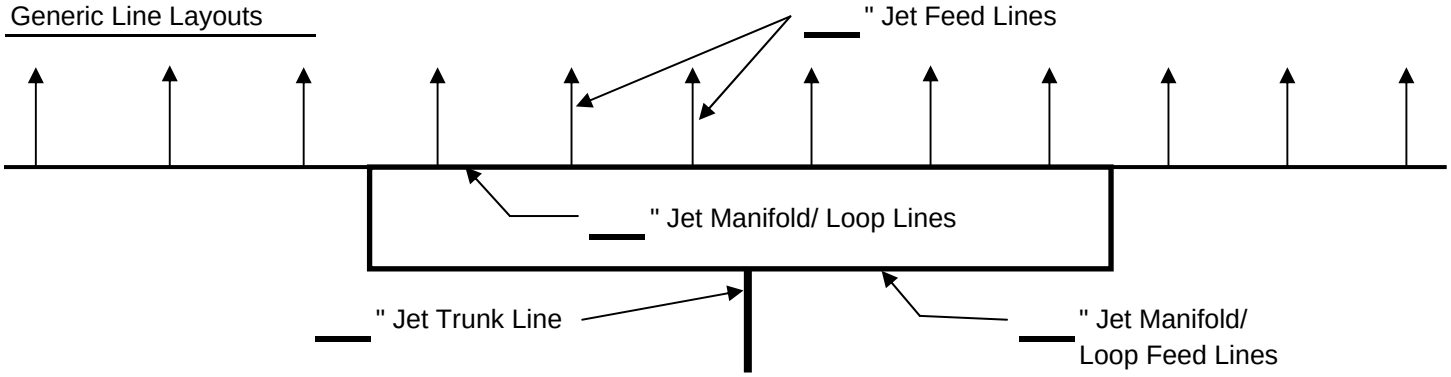
3. Calculate the Jet Trunk Line. The Trunk line GPM is then split in half for the Manifold/ Loop Feed Lines. Then select the pipe size using the new GPM at the water velocity. Repeat this for the Manifold/ Loop Lines and Jet Feed Lines.

EXAMPLE: If the GPM is 140 and you use 7 fps then you need 3" Sch 40 PVC for the Trunk Line. The Manifold/ Loop Feed Line is 70 GPM @ 7 fps giving you 2" PVC. The Manifold/ Loop Line @ 7 fps allows for 35 GPM in 1 1/2" PVC. The Jet Feed Lines are a minimum of 1" PVC at 17.5 GPM.

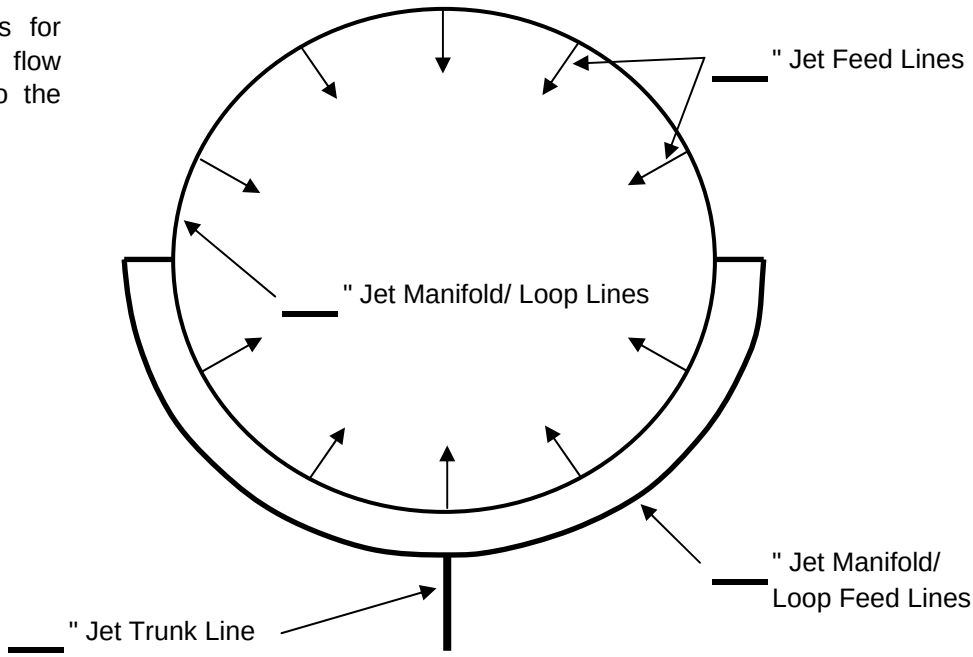


Note: When stepping down in pipe size from one section to another (Fig. 1 & 2) it is best to use a tee in the same size as the largest pipe and reduce the tee on the smaller pipe side(s). If using a manifold for your jet feeds instead of a loop, consider extending the pipe and additional 6 - 12" past the end (Fig. 3) to help balance the flow and pressure.

Generic Line Layouts



Looped plumbing allows for the best equalization of flow and pressure going into the jet feed lines

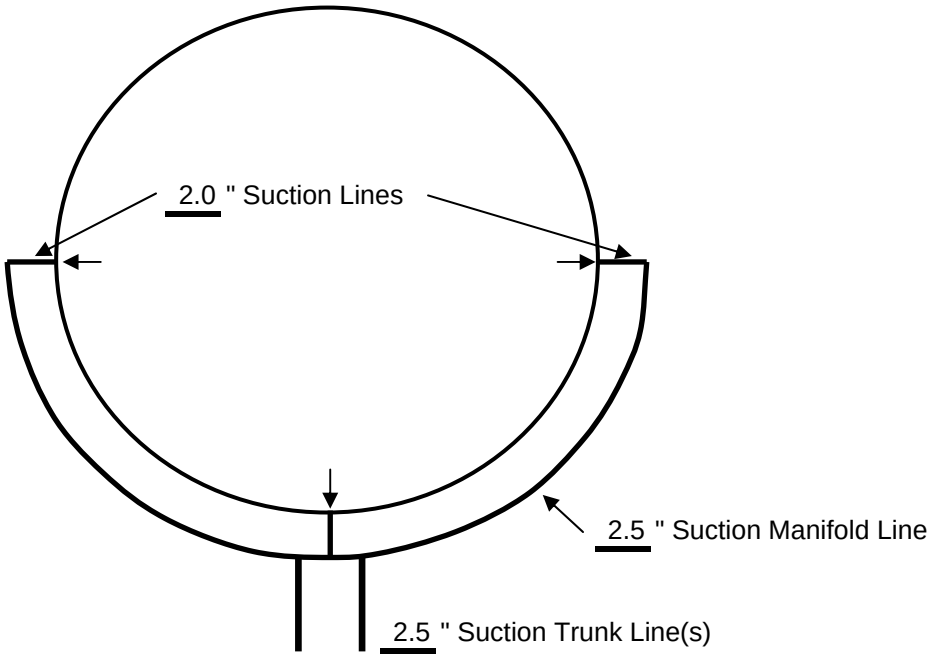


Calculating Pipe Size - Jet Suction

4. Calculate the Jet Suction Line. Once you know your jet plumbing you can calculate your suction lines for the jet pump. A velocity of 5 fps* is suggested for the suction lines. Using the Friction Flow Chart calculate the flow rate at the velocity for the size pipe being used at the suction fittings. Divide that flow rate into the Total Jet GPM and this will give you the minimum suction fittings** required. Then calculate your suction manifold and trunk line(s) in the same manner as you did for the discharge lines.

EXAMPLE: At 5 fps for 2" suction fittings (P/N 640-3240B or P/N 215-9890) you find a flow rate of 50 GPM. If the Jet GPM is 140 and you divide by 50 it gives you a minimum of 3 suction fittings. The suction manifold line is 2 1/2" PVC, based on 70 GPM (half of 140 GPM) @ 5 fps. You can use (2) 2 1/2" lines back to the pump and tee into 3" x 12" line into the pump. This would be more efficient then running a single 3" line @ 6.5 fps from the manifold back to the pump.

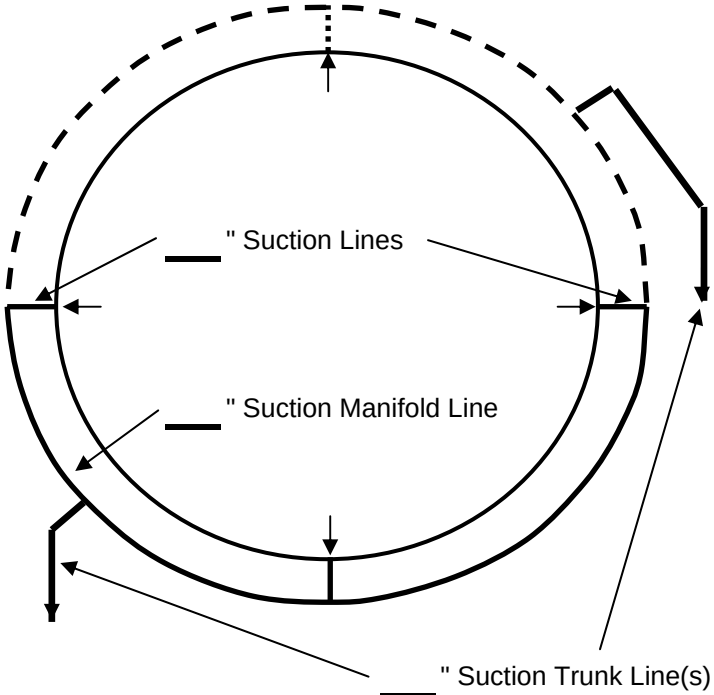
Suction fittings- qnty 3
Suction Trunk Line(s) 2



Note: Side suctions in the wall of the footwell allow for good spacing (min. of 3 ft.) between fittings, take up less space and are able to pull higher flow rates then going through floor suctions.

Generic Line Layouts

Suction fittings - qnty
Suction Trunk Line(s)



** Always use a minimum of (2) two drains per pump. Always comply with your local building code requirements.

Calculating Jet Pump Size

Jet Suction Loss

1. Resistance Head of System

From the Friction Flow Chart and the Friction Loss in Fittings, convert fittings & pipe lengths into feet of head (FoH).

EXAMPLE:

A. (4) 2.5" 90 Elbows = 4 x 9.3 = 37.2 ft. of 2.5" pipe
B. (1) 2.5" T's (thru side) = 1 x 13.0 = 13.0 ft. of 2.5" pipe
C. (1) 3" T's (thru side) = 1 x 17.1 = 17.1 ft. of 3" pipe
D. 50.2 ft. of 2.5" pipe; 17.1 ft. of 3" pipe
E. 1 ft. of 2" pipe = 1 ft.
F. 30 ft. of 2.5" pipe = 30 ft.
G. 1 ft. of 3" pipe = 1 ft.
H. 1 ft. of 2" pipe; 30 ft. of 2.5" pipe; 1 ft. of 3" pipe
D & H. 1 ft. of 2" pipe; 50.2 ft. + 30 ft. = 80.2 ft. of 2.5" pipe; 17.1 ft. + 1 ft. = 18.1 ft. of 3" pipe

	Quantity		Fitting Friction Loss		Straight Length of Pipe
A		x		=	
B		x		=	
C		x		=	
D				Total	

	Quantity		Pipe		Straight Length of Pipe
E		x		=	
F		x		=	
G		x		=	
H				Total	

			Total Pipe Length
D+H		+	=

I. Using the Friction Flow Chart, 2" pipe @ 5 fps is 50 GPM @ 4 FoH/ 100 ft. of pipe. 1'/100' = .01 x 4 = .04 FoH for 2" pipe. Doing the same for 2.5" pipe is 70 GPM @ 3.14 FoH/ 100 ft. of pipe. 80.2'/100' = .802 x 3.14 = 2.52 FoH for 2.5" pipe. 3" pipe is 150 GPM @ 4.5 FoH/ 100 ft. of pipe. 17.1'/100' = .171 x 4.5 = .77 FoH for 3" pipe.

	Total Pipe Length		Head Loss/100'		Feet of Head
I		x		=	
		x		=	
		x		=	
				Total	

Note: When calculating the resistance of multiply branches such as a manifold plumbing line find the branch with the highest FoH and use that quantity for calculating the resistance for the system.

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2. Resistance Head of Components

Refer to Head Loss Chart (pg. 7)

EXAMPLE:

1) One 2" Drain @ 50 GPM is 1.5 FoH
Total head loss of components is 1.5 feet of head

Quantity	GPM	Head Loss
	Total	

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3. Total Suction Head Loss

Add the Head Loss from 1(I) + 2 for Total Suction Head Loss

EXAMPLE:

3.33 FoH (system resistance) + 1.5 FoH (from component head loss) = 4.83 FoH

Resistance Head of System		Resistance Head of Components		Total Suction Head Loss
	+		=	

FRICTION LOSS IN FITTINGS

SIZE	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"
Gate Valve (Full Open)	0.6	0.7	0.9	1.2	1.3	1.6	1.7	2.0	2.7
Elbow - 90°	3.6	4.5	5.3	6.7	7.5	8.6	9.3	11.1	13.1
Elbow - 45°	0.7	0.9	1.4	1.8	2.2	2.8	3.2	4.1	5.6
Tee (Straight Thru)	1.8	2.5	3.3	4.7	5.7	7.8	9.3	12.1	17.1
Tee (Thru Side)	4.3	5.4	6.7	8.8	10.0	12.1	13.0	17.1	21.2
Swing Check Valve	8.1	8.9	11.2	13.1	15.2	19.1	22.0	27.1	38.2

Calculating Jet Pump Size

Jet Return Loss

Now calculate the FoH for the Discharge

1. Resistance Head of System

From the Friction Flow Chart and the Friction Loss in Fittings, convert fittings & pipe lengths into feet of head (FoH).

EXAMPLE:

A. (1) 1.5" T's (thru side) = 1 x 10.0 = 10.0 ft. of 1.5" pipe

B. (2) 1.5" T's (straight thru) = 2 x 5.7 = 11.4 ft. of 1.5" pipe

C. (1) 2" T's (thru side) = 1 x 12.1 = 12.1 ft. of 2" pipe

D. (1) 2" 90 Elbows = 1 x 8.6 = 8.6 ft. of 2" pipe

E. (1) 3" T's (thru side) = 1 x 17.1 = 17.1 ft. of 3" pipe

F. (4) 3" 90 Elbows = 4 x 11.1 = 44.4 ft. of 3" pipe

G. 21.4 ft. of 1.5" pipe; 20.7 ft. of 2" pipe; 61.5 ft. of 3" pipe

H. 3 ft. of 1" pipe = 3 ft.

I. 7 ft. of 1.5" pipe = 1.7 ft.

J. 8 ft. of 2" pipe = 8 ft.

K. 33 ft. of 3" pipe = 33 ft.

	Quantity		*Fitting Friction Loss*		*Straight Length of Pipe*
A		**x**		**=**	
B		**x**		**=**	
C		**x**		**=**	
D		**x**		**=**	
E		**x**		**=**	
F		**x**		**=**	
G				**Total**	

	Quantity		*Pipe*		*Straight Length of Pipe*
H		**x**		**=**	
I		**x**		**=**	
J		**x**		**=**	
K		**x**		**=**	
L				**Total**	

G & L. 3 ft. of 1" pipe; 28.4 ft. of 1.5" pipe; 28.7 ft. of 2" pipe; 94.5 ft. of 3" pipe

				Total Pipe Length
G & L		**+**	**=**	

M. Using the Friction Flow Chart, 1" pipe @ 7 fps is 17.5 GPM @ 19.9 FoH/ 100 ft. of pipe. 3'/100' = .03 x 19.9 = .6 FoH for 1" pipe. Doing the same for 1.5" pipe is 35 GPM @ 7 FoH/ 100 ft. of pipe. 28.4'/100' = .284 x 7 = 2.0 FoH for 1.5" pipe. 2" pipe @ 7 fps is 70 GPM @ 7.4 FoH/ 100 ft. of pipe. 28.7'/100' = .287 x 7.4 = 2.1 FoH for 2" pipe. 3" pipe is 140 GPM @ 4.5 FoH/ 100 ft. of pipe. 94.5'/100' = .945 x 4.5 = 4.25 FoH for 3" pipe.

	Total Pipe Length		*Head Loss/100'*		*Feet of Head*
M		**x**		**=**	
		x		**=**	
		x		**=**	
		x		**=**	
				Total	

Note: When calculating the resistance of multiply branches such as a manifold plumbing line find the branch with the highest FoH and use that quantity for calculating the resistance for the system.

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2. Total Resistance Head Loss

Total the Suction Head Loss (3) + Resistance Head of Return System (1M) is TRH

EXAMPLE:

4.83 FoH (total suction head loss) + 8.95 FoH (head of return system) = 13.78 FoH

Total Suction Head Loss		*Resistance Head of Return System*		*TRH*
	+		**=**	

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3. Working Jet Pressure as FoH

Refer to Jet Flow Chart or #1 of Calculating Pipe Size

EXAMPLE:

15 PSI x 2.31 = 34.65 FoH

PSI		*2.31 FoH*		*FoH*
	x		**=**	

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4. TRH plus Working Jet FoH

Total resistance head (2) + Jet FoH (3) is Total Dynamic Head

EXAMPLE:

13.78 FoH + 34.65 FoH = 48.4 FoH

TRH		*Jet FoH*		*TDH*
	+		**=**	

Calculating Jet Pump Size

Choosing A Jet Pump

Using the information you have calculated you will need a pump that will give you 140 GPM @ 48.4 FoH. Now you can take the SVL Pump Curves and make a selection on a properly sized pump for your Jet System.

SVL56

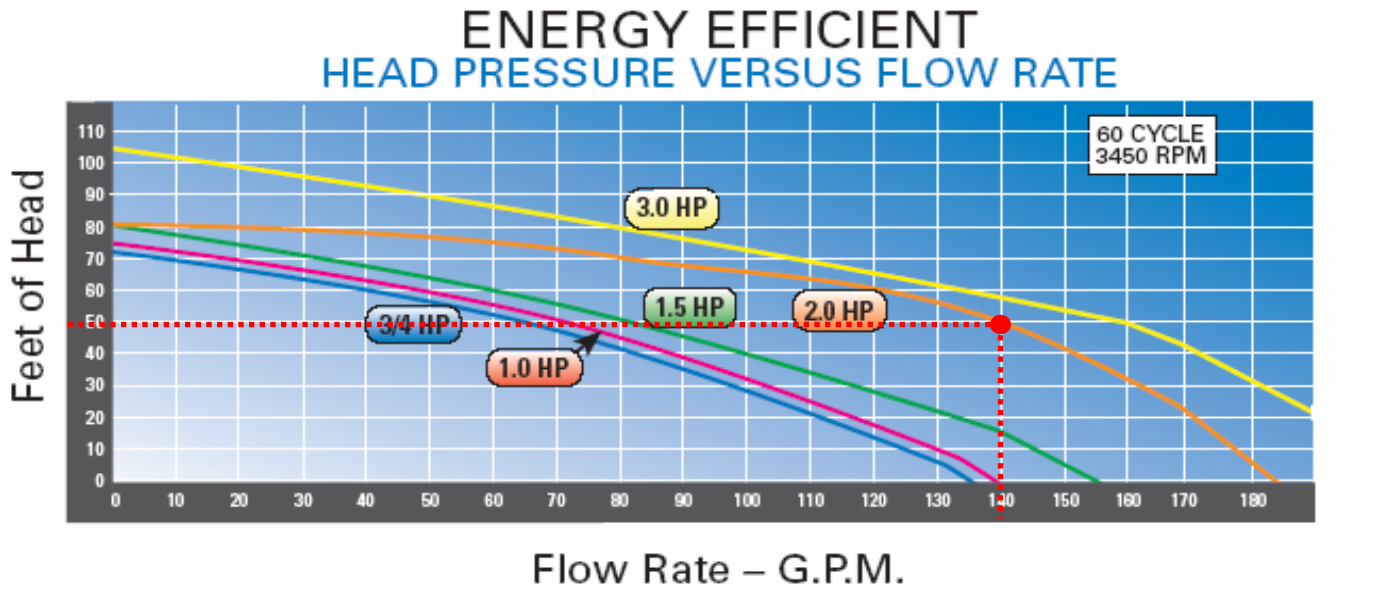
56 Frame In-Ground Pool Pump

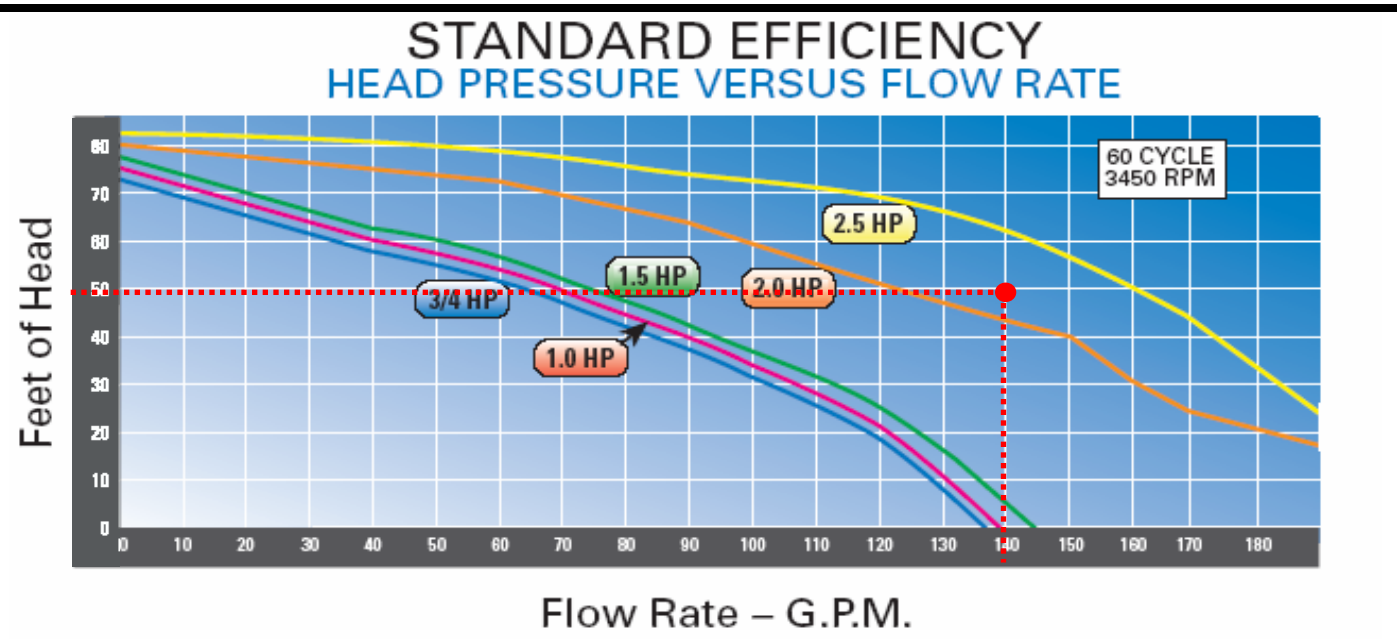
1. Plot Flow vs. FoH

Plot a line across the chart from 48.4 FoH to 140 GPM and another line from 140 GPM to 48.4 FoH. Where the lines intersect choose the closest pump curve that is above that point.

The choice of pumps that will operate this example system can be either of the following:

SVL56E-120 - 2 Hp Full Rate, Energy Efficient
SVL56S-125 - 2.5 Hp Max. Rate, Standard Efficiency
CHAMPE-130 - 3 Hp Full Rate, Energy Efficient (see catalog)





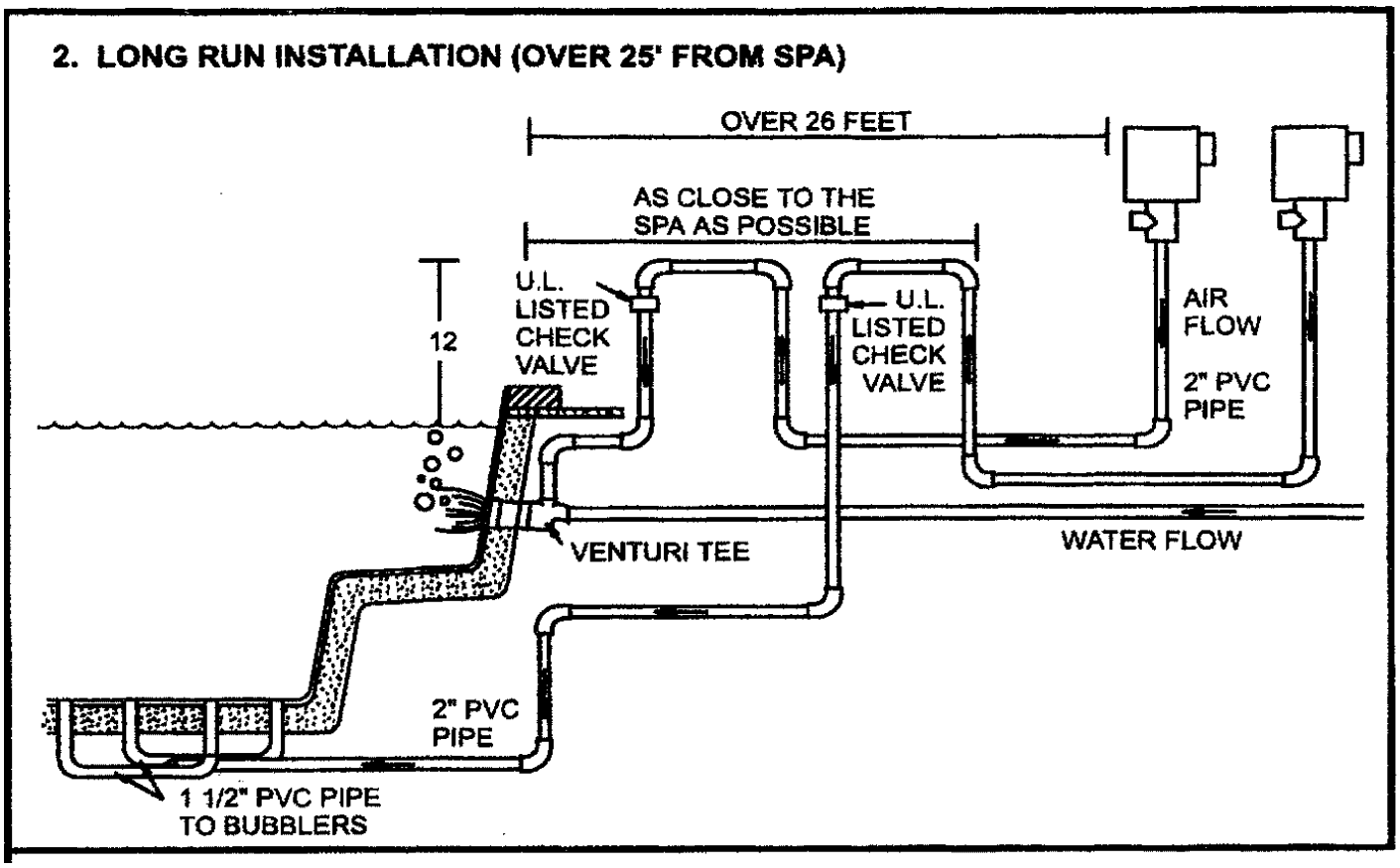
HEAD LOSS CHART

Component	GPM	Head Loss (Feet)	Component	GPM	Head Loss (Feet)
Main Drain 1½" Outlet	20	.5	Skimmer 1½" Outlet	20	1.0
	30	1.0		30	2.0
	40	1.5		40	3.0
	50	2.0		50	4.0
	60	2.5		60	5.5
Main Drain 2" Outlet	40	1.0	Skimmer 2" Outlet	20	.5
	50	1.5		30	1.0
	60	2.0		40	2.0
	70	3.0		50	3.0
	80	4.0		60	4.0
				70	5.0
Heater	--	7.0 Avg.		80	6.0

Spa Blower System Design

This section of the workbook is to help you calculate a balanced spa blower plumbing system.

TYPICAL INSTALLATION SUGGESTIONS



Calculating Water Depth

Determine the Inches of Total Water Depth (TWD) to the jet or injector, including pipe & fittings.

		Quantity				Inches of Water Depth
A. Actual water depth to the injector	**A**	Water depth to jet or injector			=	
B. Calculate 1/2" of water for every 90o L or Tee	**B**		**x**	**1/2"**	=	
C. Calculate 1/4" of water for every U-Bend (Hartford Loop)	**C**		**x**	**1/4"**	=	
D. Calculate 1/8" of water for every 45o or Sweep 90o L*	**D**		**x**	**1/8"**	=	
E. Calculate 1" of water per 10' of 2" pipe	**E**		**x**	**1"**	=	
F. Calculate 4" of water per 1/2# spring check valve	**F**		**x**	**4"**	=	
					TWD	

EXAMPLE:
30" WD + 1"(2- 90s) + 1"(8-45s/Swp 90s*) + 3/4"(3- U-Bnds) +
6"(60'- 2" pipe) + 4"(1- 1/2# spring check valve) = 42 3/4" TWD - This is the **Back Pressure** on the Blower System

*** Note:** Using Waterway Sweep 90s can reduce the restriction by up to 75%.

Calculate Air Holes

AIR HOLE SIZING CHART

Air Hole Size	Number of Holes Needed per 10 SCFM
1/8"	24
5/32"	15
3/16"	11
1/4"	6
5/16"	4
Jet	1

Using the chart calculate the SCFMs (Standard Cubic Feet per Minute) needed per the number of holes.

EXAMPLE:

		Total # of Holes		# of Holes Needed		Total
A. (4) Air Injector (P/N 672-2000) w/ 29; 1/8" holes = 116 holes	**B**		**/**		=	
B. 116 divided by 24 holes for 1/8" holes = 4.83		**Total**		**SCFMs**		**Airflow (SCFMs)**
C. 4.83 x 10 SCFMs = 48.30	**C**		**x**	**10**	=	

Calculating Air Blower Size

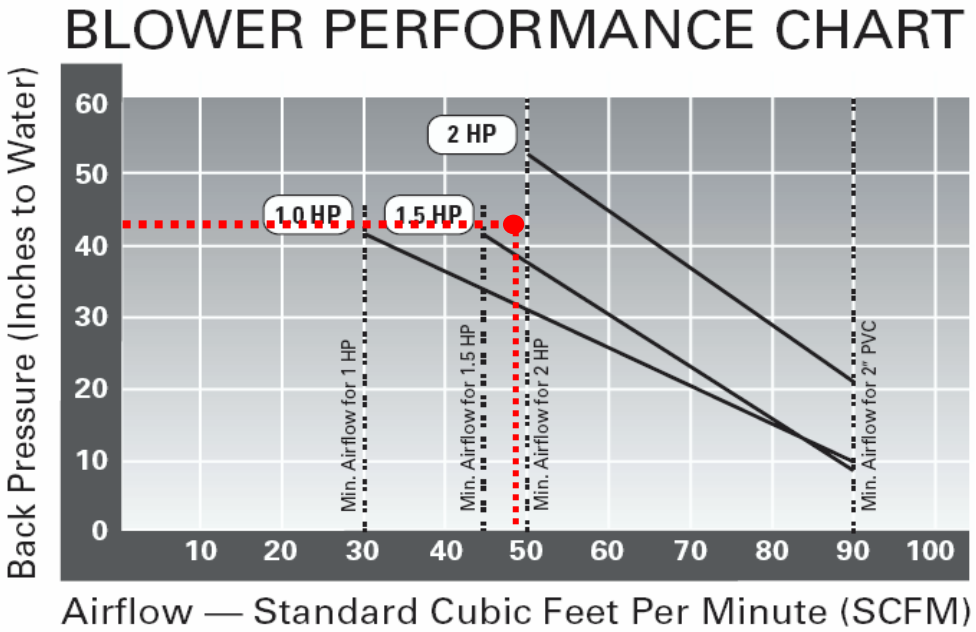
Determine the size of the blower needed from the Blower Performance Chart on the following page (pg. 10).

A. On the Blower Performance Chart, using the TWD find the number that corresponds to the Back Pressure, follow that line across.

B. Take total (SCFM) you calculated for the air hole sizes and draw a line up till it intersects with TWD.

C. At the point the lines intersect on the chart use the horsepower (H.P.) to the right of that point.

EXAMPLE:
The Back Pressure is 42-3/4" TWD & the SCFMs are 48.3, therefore the closest blower to the right is the 2 Hp.


BLOWER PERFORMANCE CHART
Back Pressure (Inches to Water)
60
50
40
30
20
10
0
2 HP
1.0 HP
1.5 HP
Min. Airflow for 1 HP
Min. Airflow for 1.5 HP
Min. Airflow for 2 HP
Min. Airflow for 2" PVC
10
20
30
40
50
60
70
80
90
100
Airflow — Standard Cubic Feet Per Minute (SCFM)